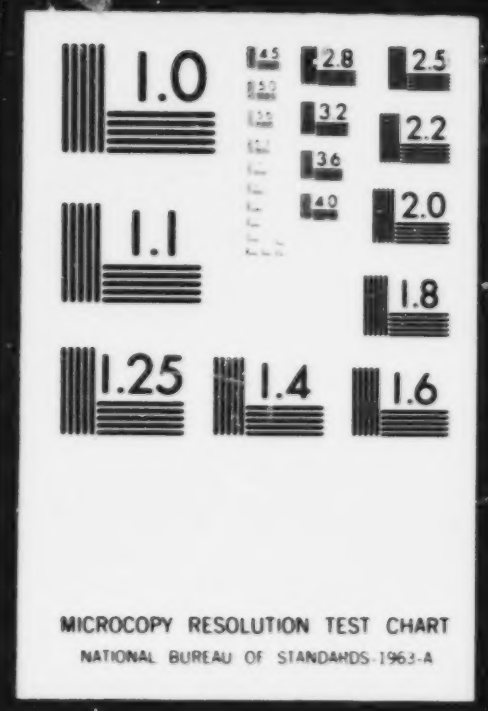
I OF I
SWRHL
87 R



RECEIVED BY DTIE OCT 21 1971

SWRHL-87r

MASTER

FINAL REPORT OF ENVIRONMENTAL SURVEILLANCE FOR PEWEE 1, EXPERIMENTAL PLANS II AND III NOVEMBER 21 AND DECEMBER 4, 1968

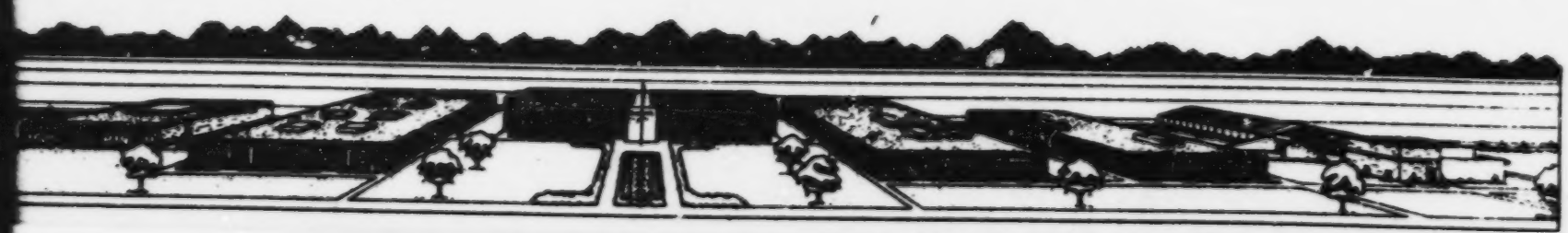
by
Environmental Surveillance
Western Environmental Research Laboratory

ENVIRONMENTAL PROTECTION AGENCY

Published September 1971

This surveillance performed under a Memorandum of
Understanding (No. SF 54 373)
for the Nevada Operations Office
U. S. ATOMIC ENERGY COMMISSION

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED



"This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, or process disclosed, or represents that its use would not infringe privately-owned rights."

Available from the National Technical Information Service,
U. S. Department of Commerce
Springfield, VA. 22151

Price: paper copy $3.00; microfiche $.95.

058

SWRHL-87r

FINAL REPORT OF ENVIRONMENTAL SURVEILLANCE FOR PEWEE 1, EXPERIMENTAL PLANS II AND III NOVEMBER 21 AND DECEMBER 4, 1968

by
Environmental Surveillance
Western Environmental Research Laboratory*

ENVIRONMENTAL PROTECTION AGENCY

Published September 1971

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

This surveillance performed under a Memorandum of Understanding (No. SF 54 373) for the Nevada Operations Office U. S. ATOMIC ENERGY COMMISSION

*Formerly part of the U. S. Department of Health, Education, and Welfare, Public Health Service, Environmental Health Service, Environmental Control Administration, Bureau of Radiological Health.

ABSTRACT

In accordance with Memorandum of Understanding SF 54 373 with the Atomic Energy Commission, the Western Environmental Research Laboratory (WERL) performed radiological monitoring and sampling in off-site areas after the testing of the Pewee 1 reactor through Experimental Plans (EP's) II and III, conducted on November 21 and December 4, respectively, at Test Cell C, Nuclear Rocket Development Station. No radioactivity was released during Experimental Plan I.

Following EP II, airborne radioactivity was detected by aircraft, but was not detected off-site on the ground by thermoluminescent dosimeters (TLD's) and Geiger-Mueller (GM) survey instruments or in air, vegetation and milk samples.

The radioactive effluent from EP III was found by aircraft and off-site surveillance to have moved east-southeast from the test area as far as northwestern New Mexico. The effluent was not detected off-site by TLD's or GM survey instruments; however, low levels of ^{131}I, $^{132}Te\text{-}I$ and ^{133}I were detected on natural vegetation and air samples. Air samples which contained reactor-related radioactivity were collected in southeastern Nevada, southern Utah, southwestern Colorado, northern Arizona, and northwestern New Mexico. Emissions from reactor pulse-cool-down operations and possibly portions of the main reactor cloud transported south by the evening drainage winds were also detected by air samplers located in southeastern California and Nevada. The maximum calculated thyroid dose from the inhalation of airborne radioiodine, based on air sampling results, occurred at Las Vegas, Nevada, where the postulated child thyroid dose was less than one mrad.

PREFACE

In accordance with Memorandum of Understanding SF-54-373, the Western Environmental Research Laboratory (WERL) provides an off-site radiological safety program for the Atomic Energy Commission in support of nuclear tests conducted at the Nevada Test Site (NTS) and at the Nuclear Rocket Development Station (NRDS), which lies adjacent to NTS. In this capacity WERL is responsible for the following during reactor tests:

1. Documenting the radiological situation in off-site areas through comprehensive environmental sampling and radiation monitoring.

2. Assuring continuous protection of public health and safety by determining potential and past exposures to radioactivity, and implementing protective measures as directed by the Test Manager, AEC.

3. Conducting a public contact and information program in the off-site area to assure local residents that all reasonable safeguards are being employed to protect public health and property from radiation hazards.

4. Collecting information regarding incidents which may be attributed to radioactive releases to the off-site area.

The off-site areas are those outside the boundaries of NTS, NRDS, the Tonopah Test Range, and the Nellis Air Force Range, which together are identified in this report as the Test Range Complex.

TABLE OF CONTENTS

	Page No.
ABSTRACT	i
PREFACE	ii
LIST OF FIGURES & TABLES	iv
INTRODUCTION	1
PROCEDURES	2
EP II RESULTS	4
Ground Monitoring	4
Air Sampling	4
Environmental Sampling	4
EP III RESULTS	7
Ground Monitoring	7
Air Sampling	7
Environmental Sampling	10
CONCLUSIONS	12
APPENDIX A. Equipment and Analytical Techniques	13
APPENDIX B. Calculations of Thyroid Dose	20
APPENDIX C. EP III - Positive Air Sampling Results	23
DISTRIBUTION	

LIST OF FIGURES

		Page No.
Figure 1.	EP II Ground Monitoring and Environmental Sampling Locations	5
Figure 2.	EP III Ground Monitoring Locations	8
Figure 3.	EP III Air Sampling Locations	9
Figure 4.	EP III Environmental Sampling Locations	11
Figure 5.	Permanent Gamma Exposure-rate Recorder Locations	14
Figure 6.	Film Badge and Thermoluminescent Dosimeter (TLD) Network	16
Figure 7.	Air Surveillance Network Locations	17

LIST OF TABLES

Table 1.	Pewee 1 Test Series - 1968	1

INTRODUCTION

The Pewee 1 nuclear reactor test series was composed of three experimental plans conducted at Test Cell C, Nuclear Rocket Development Station (NRDS). Airborne radioactivity released from the execution of Experimental Plans (EP) II and III was detected beyond the boundaries of the Test Range Complex. To document the effect that these releases had on off-site environmental levels of radioactivity, the Western Environmental Research Laboratory (WERL) conducted radiological monitoring and sampling in off-site areas. This report summarizes the monitor- and sampling techniques which were used and presents the results. The aerial monitoring and sampling missions of the U-3A and WERL aircraft are reported separately, as is the special study on reactor-released particles of high specific radioactivity.

The Pewee 1 reactor was developed and tested by the Los Alamos Scientific Laboratory as part of Project Rover, which is administered by the Space Nuclear Systems Office. The engine was designed to operate at full power of 500 Mw to test fuel elements at the high temperatures and hydrogen coolant velocities of larger reactors which can be used for rocket vehicle application. The nozzle of the Pewee reactor was directed upward ejecting the radioactive effluent to several thousands of feet above the ground. Table 1 lists the date, time, and integrated power for each experimental plan (information obtained from Los Alamos Scientific Laboratory).

Table 1. Pewee 1 Test Series - 1968

EP	Date	Time (PST)	Peak Power (Mw)	Integrated Power (Mw·sec)
I	Nov 15	1054 - 1750	$\sim 10^{-3}$	*
II	Nov 21	1358 - 1415	~500	2.47×10^{5}
III	Dec 4	1332 - 1435	~500	1.47×10^{6}

* Reactor only critical for neutronic instrument calibration and flow tests.

PROCEDURES

Prior to a reactor test at the NRDS, mobile monitoring personnel (monitors) are positioned at populated locations and on existing highways crossing the predicted effluent trajectory to measure radiation levels and collect environmental samples should airborne radioactivity be released. The monitors are equipped with radiation survey instruments, gamma-rate recorders, thermoluminescent dosimeters, portable air samplers, and supplies for collecting environmental samples. All personnel are in two-way radio contact with a control center which directs their activities.

Following a release of radioactivity, pertinent characteristics of the effluent are determined by aerial monitoring. A U.S. Air Force U-3A aircraft defines the boundaries and hot-line of the radioactive cloud, and a WERL Turbo-Beech is used to perform cloud sampling, monitoring and other documentative missions, as required. All tracking data are radioed immediately to the control center. This information, in conjunction with meteorological and on-site monitoring information, is used in directing the placement of portable air samplers, portable recorders, TLD's, and ground monitors.

Following the passage of the effluent, levels of environmental radioactivity are documented by sampling and monitoring. Monitors take radiation readings in the affected areas and collect vegetation, milk, cow feed, and water samples. Highways crossing the effluent trajectory are also monitored by a mobile scanner of high sensitivity for gamma radiation to measure the boundaries of any radioactive deposition on the ground.

Further details on equipment, procedures, and analysis techniques are given in Appendix A.

For those tests where reactors are operated near full-power, a search is made to locate, collect, and analyze particles of high specific radioactivity which are deposited on the ground downwind of the tests. The results of these studies are reported separately.

EP II RESULTS

Ground Monitoring

According to early trajectory information provided by the U-3A and Turbo-Beech aircraft, radioactive effluent moved south-southeast from Test Cell C at approximately 160° azimuth, at a speed of approximately 5 mph. The northern and southern edges were generally along the 140° and 180° azimuths, respectively. Based on this information and weather predictions, it was determined that the effluent cloud would cross Highway 95 between Lathrop Wells and the Mercury turnoff. Ten ground monitors equipped with survey instruments and gamma exposure-rate recorders were stationed along Highway 95 from 10 miles west of Lathrop Wells, Nevada (208°, 15 miles), to Indian Springs, Nevada (117°, 38 miles). Ten exposure-rate recorders were placed along Highway 95 at 5-mile intervals from 10 miles west of Lathrop Wells to 40 miles east of Lathrop Wells. Each recorder contained two thermo-luminescent dosimeters (TLD's). The recorders located at 5 and 25 miles east of Lathrop Wells failed to operate. However, the TLD's at these locations, as well as the eight other recorders and their TLD's, detected no exposures above background. Ground monitors observed no exposures above background on their survey instruments. The locations of the ground monitors and/or recorders are shown in Figure 1.

Air Sampling

In addition to the routinely operated Air Surveillance Network (ASN) stations, four portable air samplers were placed at 10 miles west and 10, 20, and 30 miles east of Lathrop Wells. The portable samplers were operated for a period of two hours beginning about one and one-half hours after the completion of the test. No airborne radioactivity related to the reactor test was collected by any of the air samplers.

Environmental Sampling

Environmental sampling for Pewee 1, EP II, involved the collection of natural vegetation and milk samples. Vegetation samples were taken at all but two exposure-rate recorder and air sampler locations. Additional

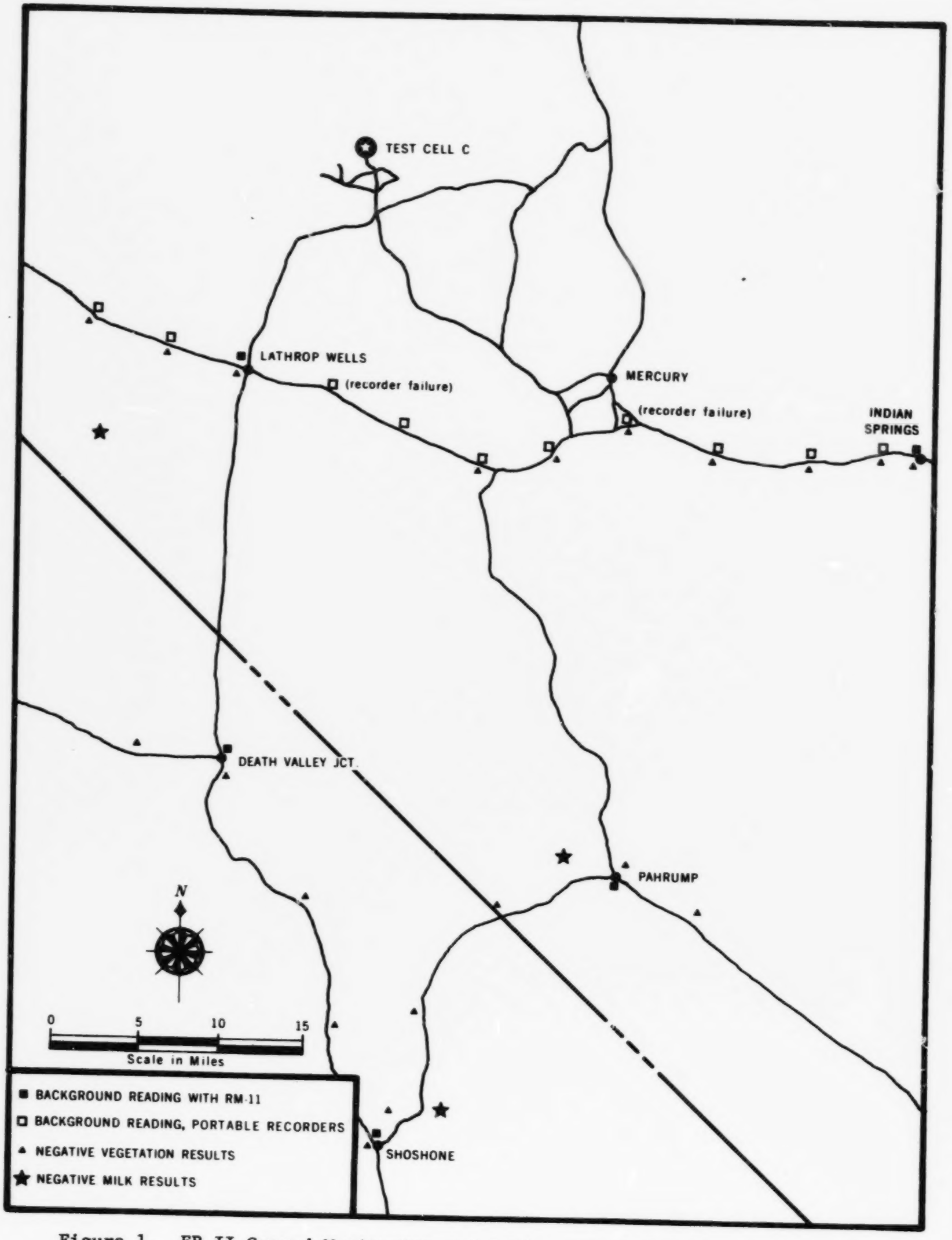


Figure 1. EP II Ground Monitoring and Environmental Sampling Locations

vegetation samples and three milk samples were collected in California and Nevada. None of the environmental samples contained any reactor-related radioactivity. Sampling locations are shown in Figure 1.

EP III RESULTS

Ground Monitoring

According to early trajectory information provided by the U-3A and Turbo-Beech aircraft, radioactive effluent moved east-southeast from Test Cell C at approximately 110° azimuth and at a speed of approximately 10 mph. The northern and southern edges were generally along the 90° and 120° azimuths, respectively. Based on this information and weather predictions, it was determined that the effluent cloud would pass between the junction of Highways 93 and 7 and Las Vegas, Nevada. Ground monitors equipped with survey instruments and gamma exposure-rate recorders were deployed to various locations in this general trajectory. Each recorder contained two TLD's. No positive results were obtained from the TLD's, recorders, or survey instruments. Locations of ground monitors, portable recorders, and permanent RM-11 stations are shown in Figure 2.

Air Sampling

To supplement the routinely operated ASN Stations, eight temporary air samplers were operated at off-site locations which were expected to contact the effluent from the test or from pulse-cool-down operations.[1] Five samplers were operated within the Amargosa Farm Area southwest of Lathrop Wells and three samplers were used at Cactus Springs, Butler Ranch (an abandoned ranch 32 miles south of Alamo, Highway 93), and Apex Junction (Jct. Highways 93 and 15). Figure 3 shows the locations of the ASN and portable air sampling stations which were positive for the reactor effluent. As indicated by this figure, the reactor effluent traveled to the east-southeast where it was detected in air samples collected in southern Utah, northern Arizona, southwestern Colorado, and northwestern New Mexico. Emissions from reactor pulse-cool-down operations and possibly portions of the main reactor cloud

---

[1] A process of removing reactor decay heat by periodic pulses of liquid or gaseous hydrogen. For this test, pulses of coolant were required until 4.7 days after shutdown. (Information obtained from Los Alamos Scientific Laboratory)

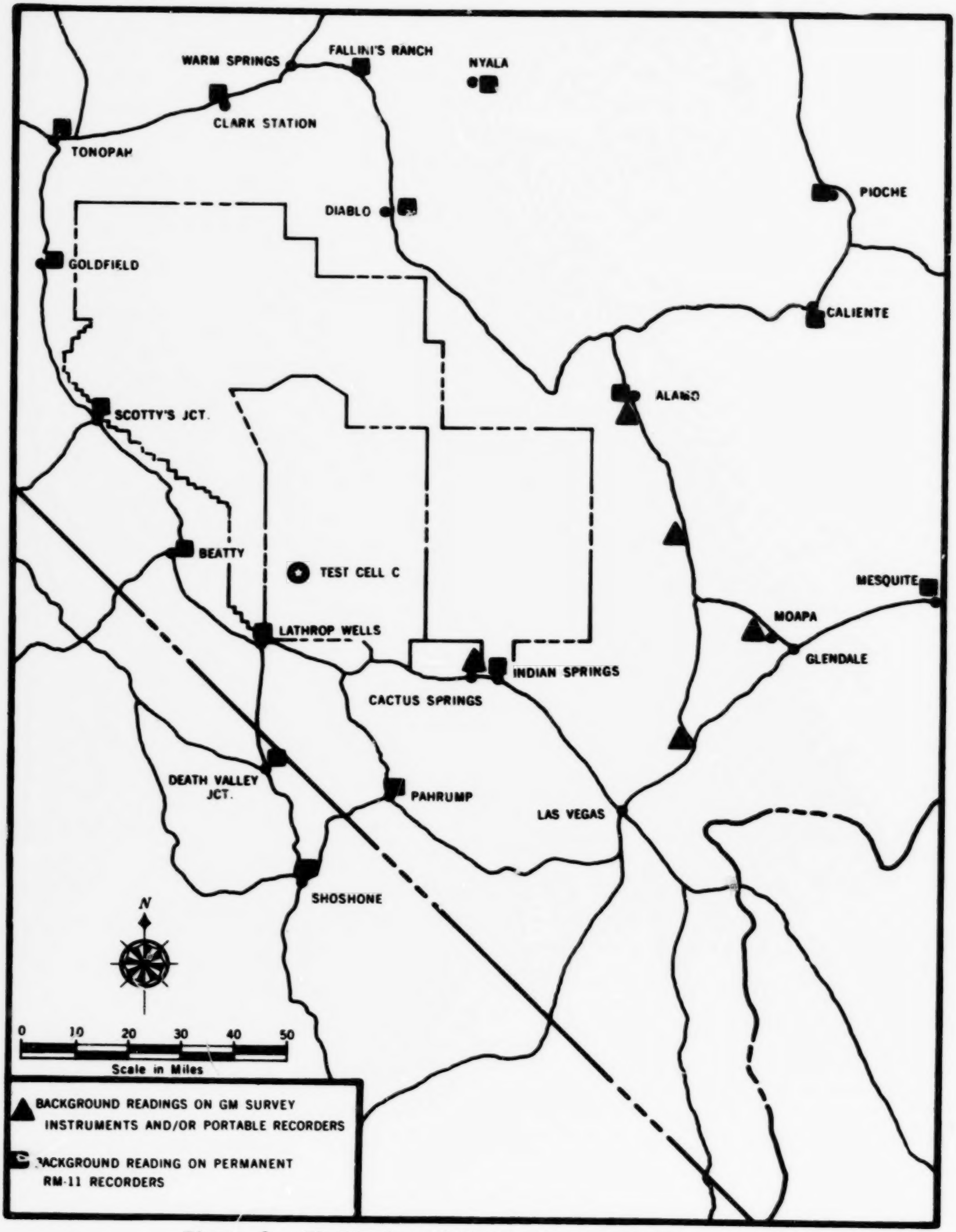


Figure 2. EP III Ground Monitoring Locations

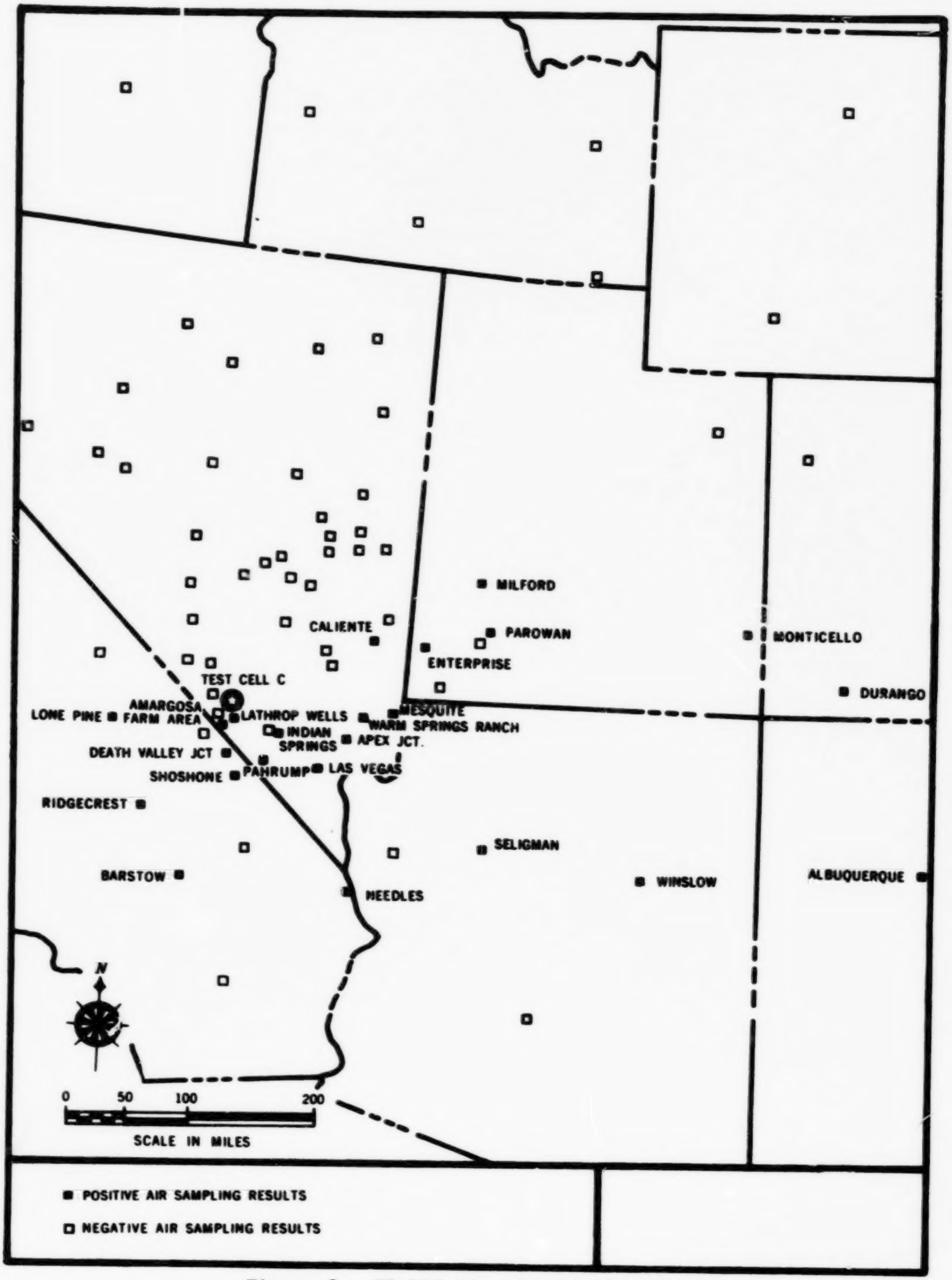


Figure 3. EP III Air Sampling Locations

transported south by the evening drainage winds were also detected by air samplers located in Nevada and California, south and southwest of Test Cell C.

All positive air sampling results are shown in Appendix C. The radioisotopes identified in the samples were various combinations of ^{131}I, ^{132}Te-I, ^{133}I and ^{141}Ce. From these results the maximum exposure to airborne radioiodine occurred at Las Vegas, Nevada. The child-thyroid dose which corresponds to the concentrations at this location was estimated to be less than one mrad by the method given in Appendix B.

Environmental Sampling

Positive samples of natural vegetation were collected along Highway 95 between Cactus Springs and Las Vegas and along Highway 93 and 15 and a point 30 miles south of Alamo. Isotopic analyses on these samples indicated the presence of ^{131}I, ^{132}Te-I, and ^{133}I in various combinations. Milk, cow feed, and water samples collected after the test over two consecutive days at Moapa, Mesquite, Las Vegas, and the Amargosa Farm Area near Lathrop Wells all yielded negative results for reactor-related radioactivity. Environmental sampling locations are shown in Figure 4. Positive or negative designations indicate the presence or absence of reactor-related activity in the corresponding samples.

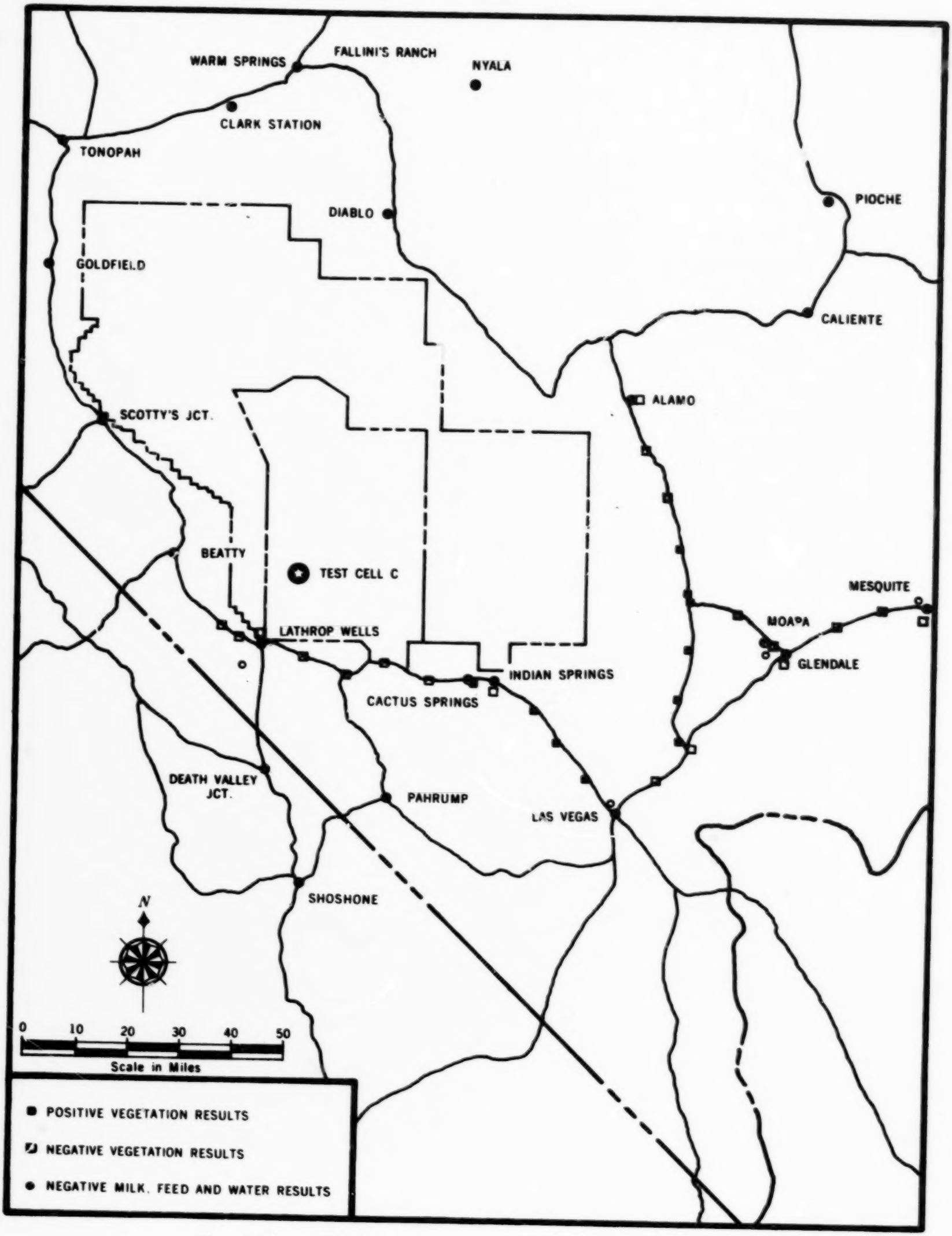


Figure 4. EP III Environmental Sampling Locations

CONCLUSIONS

Although detected over the test site by the cloud tracking aircraft, the activity of the Pewee 1, EP II, effluent was below detectable limits at ground level in the off-site area. Aerial monitoring results indicated that the maximum activity was 0.4 mR/h at 6600 feet above the ground at 15 miles from Test Cell C. This high rise of the effluent together with the low levels of radioactivity at this altitude explain why the effluent was not detectable on the ground.

As in EP II, the high rise of the EP III effluent resulted in no radioactivity in the off-site area that could be detected by survey instruments and dosimeters on the ground. However, activity was found on natural vegetation and air samples. The estimated maximum child-thyroid dose from inhalation was less than one mrad. This dose was calculated from air sampling results at Las Vegas, Nevada, and is well below the guidelines set by the Atomic Energy Commission Manual, Chapter 0524, "Standards for Radiation Protection."

APPENDIX A

Equipment and Analytical Techniques

Survey Instruments

The aircraft and ground monitors are equipped with Geiger-Mueller, gamma scintillation, and ionization chamber survey instruments. The Geiger-Mueller (GM) instrument has a range of 0-200 mR/h on four linear scales with a range of 0-2000 mR/h provided by an internal GM detector. The gamma scintillation instrument, used for low-level cloud passage measurements, has a range of 0-3 mR/h on four linear scales. The ionization chamber survey instrument is used for high radiation levels. It has a range of 0.05 to 50,000 mR/h on two logarithmic scales. These instruments are calibrated with ^{137}Cs and are generally accurate to $\pm$ 20% with regard to this calibration. Exposure-rate readings are read to two significant digits.

Mobile Ground Scanner

The mobile ground scanner consists of a 4- by 4-inch NaI(Tl) crystal connected to a battery-powered scaler. The scanner and crystal are placed within a motor vehicle and operated by taking one-minute counts at pre-selected intervals while the vehicle moves at a fixed speed along highways crossing the effluent trajectory. These data are then compared with background levels determined prior to tests to identify any deposition pattern.

Gamma-Exposure-Rate Recorders

A network of 27 continuously operated gamma-exposure-rate recorders (Eberline RM-11) are located around the Test Range Complex at the locations shown in Figure 5. These instruments measure radiation exposure-rates over a range of 0.01 to 100 mR/h with a Geiger-Mueller detector and record the levels on a 30-hour strip chart. The instrument is accurate to $\pm$ 20% as calibrated with a ^{137}Cs source.

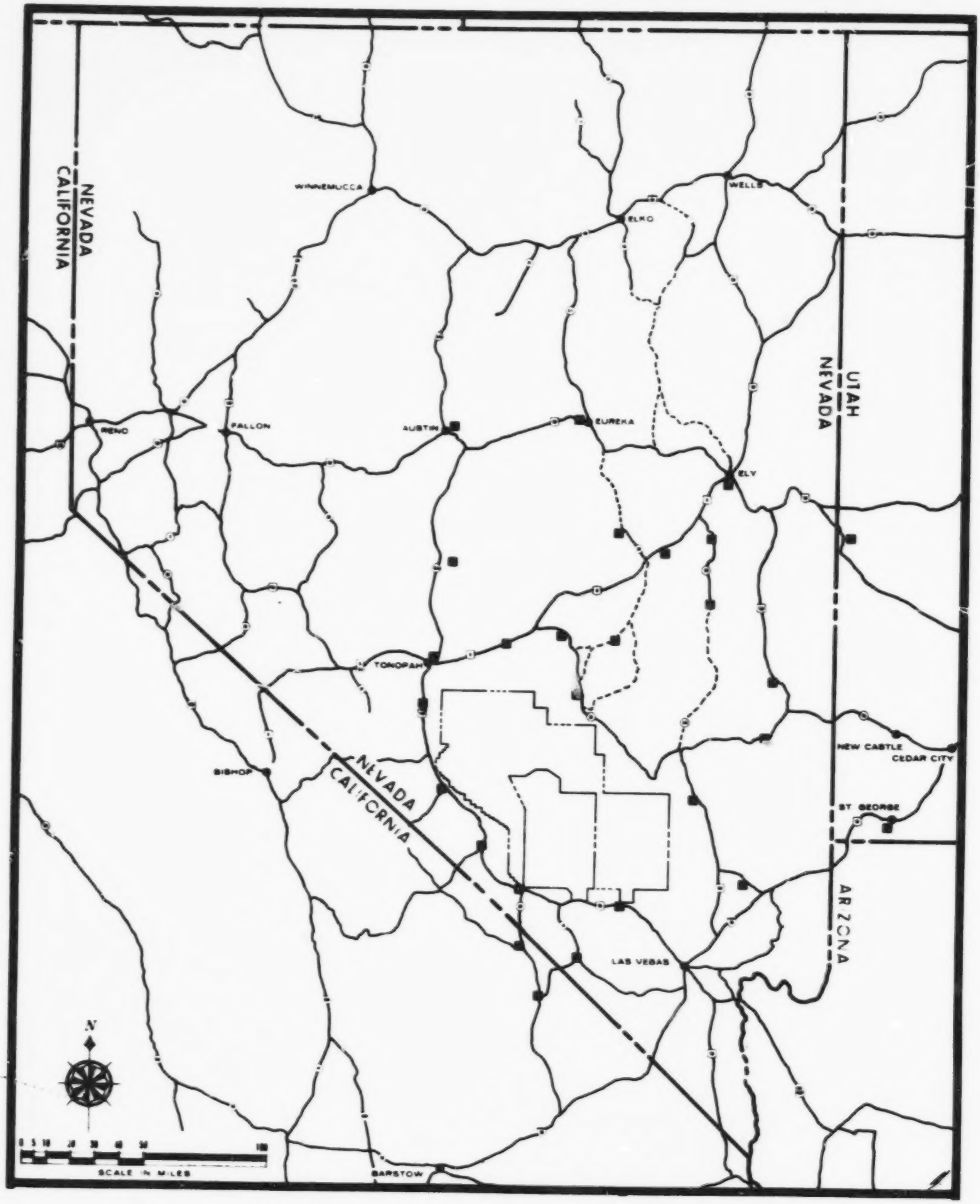


Figure 5. Permanent Gamma Exposure-rate Recorder Locations

Portable gamma-exposure-rate recorders carried by monitors utilize the same 0-2000 mR/h Geiger-Mueller survey instrument mentioned above coupled to a battery-powered strip-chart recorder. These recorders are used to supplement the routine network of gamma-exposure-rate recorders and the radiation readings taken by monitors. The enclosure for each recorder also contains two TLD's of the type described below.

Dosimeters

A network of film badges and thermoluminescent dosimeters (TLD's) surrounding the Test Range Complex is operated continuously. This network, shown in Figure 6, consists of 106 stationary film badge stations with 5 badges at each location. Additionally, about 140 off-site residents are provided with one badge each. The badges contain Dupont Type 545 film, which is calibrated with a ^{137}Cs source. The film has a lower detection limit of 30 mR with a reading accuracy of $\pm$ 50% from 30 mR to 100 mR and $\pm$ 10% from 100 to 2000 mR for gamma radiation above 50 keV. In addition, 88 of the stationary stations are each equipped with three EG&G Model TL-12 thermoluminescent dosimeters. The minimum sensitivity of the TLD is approximately 1 mR. The TLD system (TLD and reader) is capable of detecting exposures up to 5000 R. The TLD system is calibrated with a ^{137}Cs source and has an overall accuracy of $\pm$ 10%.

Following nuclear tests which release airborne radioactivity, additional TLD's are placed at intervals along highways crossing the effluent trajectory and at populated locations to supplement the monitoring coverage of the routine dosimetry network.

Air Samples

The routine network of 103 permanent air samplers of the Air Surveillance Network (ASN) is used for measuring concentrations of airborne radioactivity on a daily basis. These samplers (Figure 7) operate at about 10 cfm,

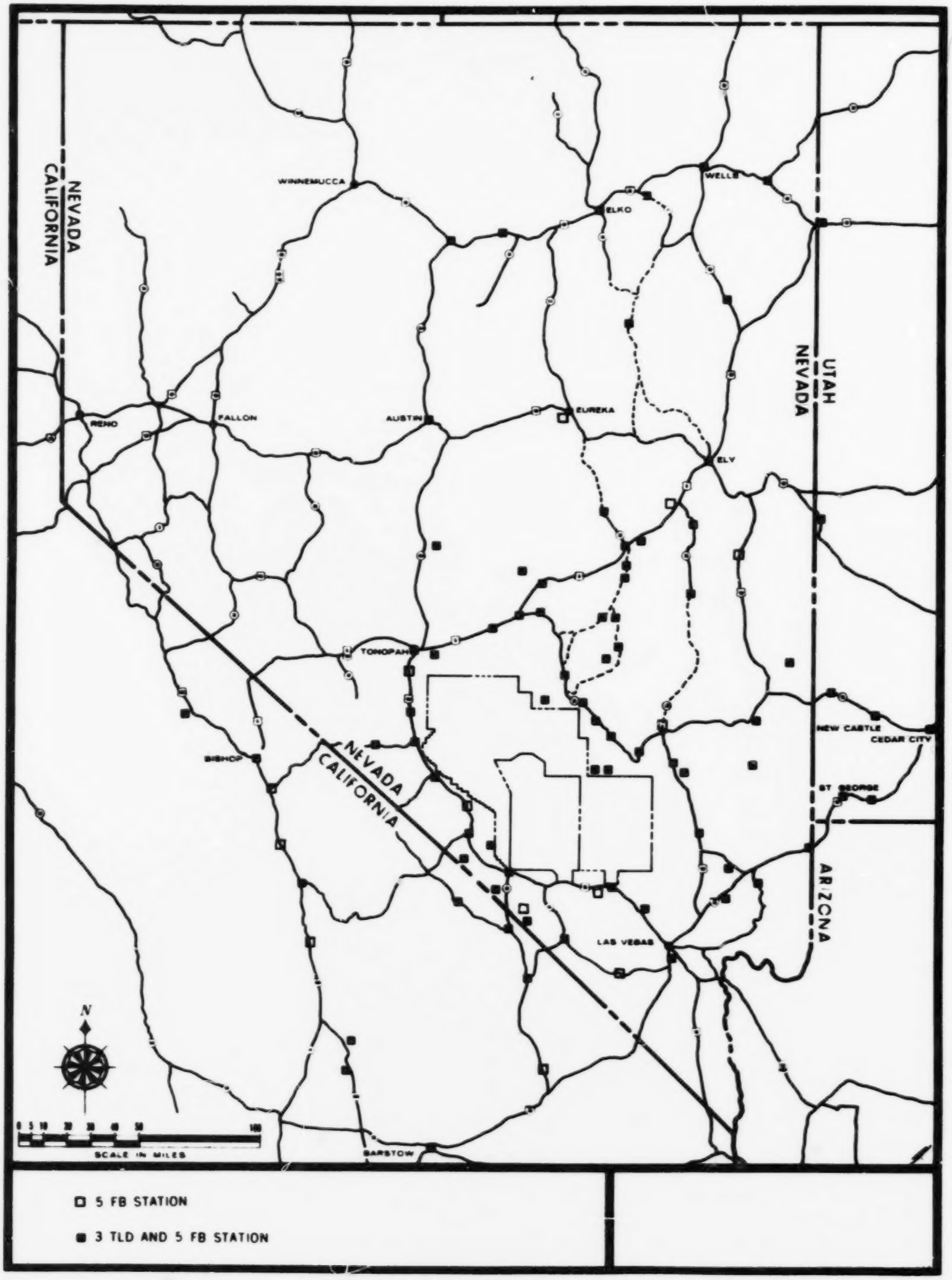


Figure 6. Film Badge and Thermoluminescent Dosimeter (TLD) Network

Figure 7. Air Surveillance Network Locations

collecting airborne particles on 4-inch diameter glass-fiber filters. Twenty-two of the samplers at stations next to the Test Range Complex each operate routinely with a 4-inch diameter charcoal cartridge following the particulate filter. By telephone request, charcoal cartridges can be placed in remaining stations and stand-by stations can be activated.

Portable air samplers carried by field monitors supplement the ASN stations to cover cloud passage. These samplers also use 4-inch diameter glass-fiber filters and charcoal cartridges and operate at about 12 cfm.

All particulate filters are counted for gross beta radioactivity on a low background, thin-window, proportional counter. Results are reported in pCi/m^3 and $\mu Ci \cdot sec/m^3$, extrapolated to end of collection time. Those particulate filters containing reactor-related radioactivity and all charcoal cartridges are analyzed by gamma spectrometry with a 4- by 4-inch NaI(Tl) crystal and multi-channel analyzer. The concentrations of individual radioisotopes are reported in pCi/m^3 and $\mu Ci \cdot sec/m^3$, extrapolated to end of collection. For gross beta and radioiodine radioactivity collected from $300m^3$ of air the minimum detectable activity (MDA) is 0.1 pCi/m^3 for counting times of 2 minutes, and 10 minutes, respectively.

Vegetation Samples

Following cloud passage, samples of natural vegetation are collected along highways and at populated locations to augment or substantiate other evidence of the radioactive deposition pattern. The samples are counted for gross gamma radioactivity and are qualitatively analyzed by gamma spectrometry to determine whether or not they contain test-related radioactivity.

Samples of cow feed are collected at all milk sampling locations and

are analyzed by gamma spectrometry. The concentrations of individual radioisotopes identified in the samples are reported in pCi/kg if greater than the MDA of 50 pCi/kg for a 10-minute count and sample weight of 1 kg.

Milk Samples

One-gallon milk samples are collected from dairy farms and family milk cows located within the cloud path. Samples of 3.5 liters are analyzed by gamma spectrometry techniques. The lower limit of detection for ^{131}I and ^{133}I is about 20 pCi/l for a 20-minute counting time. Samples containing test-related radioactivity are also analyzed by radiochemistry techniques for ^{89}Sr and ^{90}Sr, which have MDA's of 5 pCi/l and 2 pCi/l, respectively.

Water Samples

One-gallon water samples are collected from stock tanks and potable water sources at milk sampling locations within the effluent trajectory. All samples are analyzed by gamma spectrometry. Those samples containing test-related radioactivity are also analyzed by radiochemistry methods for ^{89}Sr and ^{90}Sr. The minimum detectable concentrations are the same as those for milk.

APPENDIX B

Calculations of Thyroid Dose

The dose rate to the thyroid may be described by the equation

$dD/dt = K\ E\ A \exp -(\lambda_{eff} t)$ where:

- dD/dt = dose rate per unit time
- K = dimensional constant
- E = effective energy of beta and gamma radiation, MeV per disintegration
- A = concentration of radioiodine in thyroid, μCi/g
- λ_{eff} = effective decay constant, 1/unit time
- t = time after deposition in thyroid

This assumes that the radioiodine is uniformly distributed throughout the thyroid and that the size of the thyroid is large compared to the range of the beta particles.

The total dose is estimated by integrating the above equation from time zero to infinity assuming D = 0 at time zero.

$$D = KEA \int_0^\infty \exp -(\lambda_{eff} t)\, dt$$

$$D = (-1/\lambda_{eff})\ KEA \exp -(\lambda_{eff} t) \Big|_0^\infty$$

$$D = 0 + KEA/\lambda_{eff}$$

Dose from Inhalation of Radioiodines

The actual values for the parameters in the dose equation for ^{131}I are as follows:

$$K = \frac{1\ rad}{100\ erg/g} \times \frac{erg}{6.24 \times 10^5\ MeV} \times \frac{3.7 \times 10^4\ dis}{\mu Ci \cdot sec} \times \frac{8.64 \times 10^4\ sec}{day}$$

$$K = \frac{51.2\ rad \cdot g \cdot dis}{MeV \cdot \mu Ci \cdot day}$$

$E = 0.23\ \text{Mev}^a$

$A = \frac{\chi B f}{m}$, where:

χ = time-integrated concentration of radioactivity, $\mu Ci \cdot sec/m^3$

B = breathing rate of standard man, $2.32 \times 10^{-4} m^3/sec^a$ (averaged over 24 hours)

f = fraction of inhaled radioiodine reaching the thyroid, 0.23 (11)

m = thyroid weight of standard man, 20 g

$$A = \frac{(2.32 \times 10^{-4} m^3/sec)(0.23)\chi}{20\ g}$$

$\lambda_{eff} = 0.693/(\text{effective half-life for } ^{131}I)$

$\lambda_{eff} = (0.693)/7.6 \text{ days (a)}$

Substituting these parameters, the dose equation becomes:

$$D = \frac{(51.2)(0.23)(2.32 \times 10^{-4})(0.23)(7.6)\chi}{(20)(0.693)}$$

$$D(rads) = (3.45 \times 10^{-4} \frac{rads \cdot m^3}{\mu Ci \cdot sec}) \chi \ (\frac{\mu Ci \cdot sec}{m^3})$$

$$\text{or,} \quad D(mrad) = (0.35 \frac{mrad \cdot m^3}{\mu Ci \cdot sec}) \chi \ (\frac{\mu Ci \cdot sec}{m^3})$$

For the dose to a child's thyroid the above equation must be multiplied by a factor of 3 to account for differences in thyroid weight and breathing rates (m^3/day) between an adult and a child (3 = 20 g/2 g x 6 m^3/20 m^3).

For other radioiodines the dose equation changes according to differences in effective half-life and effective decay energies. The dose equations for ^{133}I and ^{135}I are as follows:

---

[a] "Recommendations of the International Commission on Radiological Protection Report of Committee II on Permissible Dose for Internal Radiation." ICRP-2. Pergamon Press, New York, London, Paris, Los Angeles, 1959.

^{133}I, D(mrad) = $\frac{(0.093\ \text{mrad}\cdot\text{m}^3)}{\mu\text{Ci}\cdot\text{sec})}\chi$

^{135}I, D(mrad) = $(0.029\ \frac{\text{mrad}\cdot\text{m}^3}{\mu\text{Ci}\cdot\text{sec}})\chi$

In addition to differences in effective half-life and effective beta particle energies, the dose equation for ^{132}I is effected by the rapid decay of ^{132}I in the blood stream before it gets to the thyroid and by the decay of inhaled ^{131}Te to ^{132}I.[b] With these effects incorporated, the dose equation for ^{132}I becomes

$$D(\text{mrad}) = (5.1 \times 10^{-2}\ \text{mrad}\cdot\text{m}^3/\mu\text{Ci}\cdot\text{sec})\chi$$

where χ is the time-integrated concentration of ^{132}Te.

a. "Protection of the Public in the Event of Radiation Accidents." Proceedings of a seminar sponsored by FAO/UN, 1 AEA, and World Health Organization on 18 November, 1963 at Geneva, Switzerland, 1965. p. 210.

b. LeGrand, J. and Dousset, M. "Evolution DuDebit D'Equivalent De Dose Deliveree A La Glande Thyroide Agres Inhalation Instantanee De Tellure 132 (French)." Health Physics Vol. 12, No. 10 October, 1966. p. 1407.

APPENDIX C. EP III - Positive Air Sampling Results

(Activity Extrapolated to End of Collection Period)

LOCATION Azimuth	Distance	TIME on off	DATE on off	SAMPLING PERIOD* (hours)	TIME-DATE OF GAMMA SCAN	COLL. MEDIUM	GROSS BETA (pCi/m³) (μCi·sec/m³)	ISOTOPIC RESULTS (pCi/m³), (μCi·sec/m³) 131 I	132 Te	133 I	135 I	141 Ce
Caliente, Nevada		0630	12/4	25.4	9 1620	PF	0.4 / 0.04	ND	ND	ND	ND	ND
061	111	0800	12/5		9 1637	CC		ND	ND	ND	ND	ND
		0800	12/5	24.0	9 1512	PF	4.7 / 0.40	0.3 / 0.03	1.2 / 0.10	ND	ND	ND
		0830	12/6		9 1738	CC		ND	ND	ND	ND	ND
		0830	12/6	25.5	9 1512	PF	LT(0.2)	ND	ND	ND	ND	ND
		1000	12/7		9 1658	CC		ND	ND	ND	ND	ND
Indian Springs, Nev		0900	12/4	24.0	9 0917	PF	3.7 / 0.32	ND	ND	ND	ND	ND
117	38	0900	12/5		29 1924	CC		ND	ND	ND	ND	ND
		0900	12/5	24.0	11 1505	PF	19 / 1.6	1.8 / 0.16	8.9 / 0.77	ND	ND	ND
		0900	12/6		17 2215	CC		ND	ND	ND	ND	ND
		0900	12/6	24.0	11 1344	PF	20 / 1.7	0.9 / 0.08	3.8 / 0.32	ND	ND	ND
		0900	12/7		29 1920	CC		ND	ND	ND	ND	ND
		0900	12/7	24.0	17 2035	PF	3.4 / 0.29	0.3 / 0.03	0.9 / 0.08	ND	ND	ND
		0900	12/8		29 1935	CC		ND	ND	ND	ND	ND
		0900	12/8	24.1	12 1820	PF	1.4 / 0.12	0.1 / 0.009	0.5 / 0.04	ND	ND	ND
		0900	12/9		28 1335	CC		ND	ND	ND	ND	ND

APPENDIX C, EP III - Positive Air Sampling Results

(Activity Extrapolated to End of Collection Period)

LOCATION Azimuth	Distance	TIME on off	DATE on off	SAMPLING PERIOD* (hours)	TIME-DATE OF GAMMA SCAN	COLL. MEDIUM	GROSS BETA (pCi/m³ / μCi·sec/m³)	ISOTOPIC RESULTS (pCi/m³) / (μCi·sec/m³) 131 I	132 Te	133 I	135 I	141 Ce
(cont) Indian Springs, Nev		0900	12/9	24.1	17 2152	PF	1.5 0.13	ND	ND	ND	ND	ND
117	38	0900	12/10		17 2145	CC		ND	ND	ND	ND	ND
Las Vegas, Nevada		1100	12/4	21.0	5 1121	PF	0.2 0.02	ND	ND	ND	ND	ND
128	82	0800	12/5		6 2030	CC		ND	ND	ND	ND	ND
		0300	12/5	24.0	8 1335	PF	63 5.5	2.1 0.18	10 0.86	7.0 0.60	ND	ND
		0800	12/6		10 1128	CC		1.3 0.11	ND	ND	ND	ND
		0800	12/5	72.0	9 1041	PF	5.0 1.3	0.6 0.15	2.8 0.72	0.4 0.1	ND	ND
		0800	12/9		29 2022	CC		ND	ND	ND	ND	ND
		0800	12/9	24.0	17 2057	PF	0.8 0.07	ND	ND	ND	ND	ND
		0800	12/10		10 1830	CC		ND	ND	ND	ND	ND
Apex, Nevada Junction Hwy.93/15		1718	12/4	18.7	6 1315	PF	97 6.5	0.6 0.04	5.3 0.36	8.6 0.58	ND	ND
110	83	1200	12/5		5 1535	CC		ND	ND	0.7 0.05	ND	ND
Lathrop Wells, Nevada		1645	12/3	38.1	5 1828	PF	77 10	0.9 0.1	5.3 0.73	0.7 0.1	ND	ND
208	15	0640	12/5		5 1738	CC		0.9 0.1	ND	4.9 0.67	ND	ND
		0640	12/5	23.9	11 1505	PF	3.9 0.34	0.3 0.03	2.0 0.17	ND	ND	ND
		0640	12/6		10 1215	CC		ND	ND	ND	ND	ND

APPENDIX C. EP III - Positive Air Sampling Results

(Activity Extrapolated to End of Collection Period)

LOCATION		TIME on	DATE on	SAMPLING	TIME-DATE	COLL.	GROSS BETA (pCi/m^3 _ _)	ISOTOPIC RESULTS (pCi/m^3), ($\mu Ci \cdot sec/m^3$)				
Azimuth	Distance	off	off	PERIOD* (hours)	OF GAMMA SCAN	MEDIUM	($\mu Ci \cdot sec/m^3$)	131 I	132 Te	133 I	135 I	141 Ce
(cont)					X	PF	0.9	No Gamma Scan				
Lathrop Wells, Nevada		0650	12/6	26.3	X		0.08					
					28	CC		ND	ND	ND	ND	ND
208	15	0915	12/7		1555							
					17	PF	2.5	ND	ND	ND	ND	ND
		0915	12/7	22.0	2018		0.19					
					28	CC		ND	ND	ND	ND	ND
		0715	12/8		1500							
					12	PF	0.9	0.1	0.4	ND	ND	ND
		0715	12/8	24.3	1820		0.08	0.009	0.03			
					28	CC		ND	ND	ND	ND	ND
		0745	12/9		1250							
					17	PF	0.9	ND	ND	ND	ND	ND
		0745	12/9	23.0	2152		0.08					
					17	CC		ND	ND	ND	ND	ND
		0645	12/10		2055							
					5	PF	82	2.0	11	11	ND	ND
Lathrop Wells, Nevada		1420	12/4	22.2	1825		5.8	0.16	.88	.88		
Copeland Ranch					5	CC		1.4	ND	7.3	ND	ND
208	26	1225	12/5		1737			0.11		0.58		
					5	PF	87	2.3	15	13	ND	ND
Lathrop Wells, Nevada		1445	12/4	20.6	1825		6.5	0.17	1.1	0.96		
Henderson Ranch					5	CC		1.9	ND	13	ND	ND
286	25	1134	12/5		1737			0.14		0.96		
					5	PF	86	0.9	8.6	6.3	ND	ND
Lathrop Wells, Nevada		1430	12/4	21.6	1841		6.7	0.07	0.67	0.49		
Tracy Smith Ranch					5	CC		0.9	ND	5.5	ND	ND
297	26	1210	12/5		1745			0.07		0.43		
					5	PF	30	0.9	7.6	5.9	ND	ND
Lathrop Wells, Nevada		1407	12/4	22.6	1841		2.5	0.07	0.62	0.48		
John Mills Ranch					5	CC		0.8	ND	3.8	ND	ND
219	19	1240	12/5		1724			0.065		0.31		

APPENDIX C EP III - Positive Air Sampling Results

(Activity Extrapolated to End of Collection Period)

LOCATION		TIME on off	DATE on off	SAMPLING PERIOD* (hours)	TIME-DATE OF GAMMA SCAN	COLL. MEDIUM	GROSS BETA (pCi/m^3 / $\mu Ci \cdot sec/m^3$)	ISOTOPIC RESULTS (pCi/m^3) / ($\mu Ci \cdot sec/m^3$)				
Azimuth	Distance							131 I	132 Te	133 I	135 I	141 Ce
Mesquite, Nevada		1600	12/4	16.2	9 0917	PF	LT(0.2)	ND	ND	ND	ND	ND
091	123	0800	12/5		17 2305	CC		ND	ND	ND	ND	ND
		0800	12/5	24.0	11 1523	PF	1.9 0.17	0.7	ND 0.06	ND	ND	ND
		0800	12/6		17 2233	CC		ND	ND	ND	ND	ND
		0800	12/6	24.0	11 1415	PF	9.8 0.85	1.7 0.06	7.5 0.2	ND	ND	ND
		0800	12/7		28 1300	CC		ND	ND	ND	ND	ND
		0800	12/7	24.0	17 2018	PF	4.0 0.34	0.4 0.03	1.0 0.09	ND	ND	ND
		0800	12/8		X X	CC	- No GC run -					
		0800	12/8	24.0	12 1805	PF	1.7 0.15	0.3 0.03	0.9 0.08	ND	ND	0.1 0.009
		0800	12/9		X X	CC	No CC run					
		0800	12/9	23.0	17 2133	PF	1.6 0.14	ND	ND	ND	ND	ND
		0800	12/10		X X	CC	No CC run					
Warm Springs Ranch, Nevada		0700	12/4	24.0	9 0935	PF	0.7 0.06	ND	ND	ND	ND	
095	87	0700	12/5		28 0840	CC		ND	ND	ND	ND	
		0700	12/5	24.0	11 1523	PF	5.9 0.51	0.4 0.03	1.7 0.15	ND	ND	
		0700	12/6		17 2330	CC		ND	ND	ND	ND	

APPENDIX C. EP III - Positive Air Sampling Results

(Activity Extrapolated to End of Collection Period)

LOCATION		TIME on	DATE on	SAMPLING PERIOD *	TIME-DATE OF GAMMA SCAN	COLL. MEDIUM	GROSS BETA (pCi/m^3) ($\mu Ci \cdot sec/m^3$)	ISOTOPIC RESULTS (pCi/m^3), ($\mu Ci \cdot sec/m^3$)				
Azimuth	Distance	off	off	(hours)				131 I	132 Te	133 I	135 I	141 Ce
Warm Springs Ranch, Nevada (cont)		0700	12/6	24.0	10 2110	PF	6.7 .58	0.4 0.03	1.6 0.14	ND	ND	ND
095	87	0700	12/7		28 1535	CC		ND	ND	ND	ND	ND
		0700	12/7	24.0	X X	PF	1.4 0.12	No Gamma Scan				
		0700	12/8		29 1731	CC		ND	ND	ND	ND	ND
		0700	12/8	24.0	12 1745	PF	1.0 0.08	0.3 0.03	0.7 0.06	ND	ND	ND
		0700	12/9		28 1510	CC		ND	ND	ND	ND	ND
		0700	12/9	24.0	17 2133	PF	3.8 0.33	ND	ND	ND	ND	ND
		0700	12/10		17 2055	CC		ND	ND	ND	ND	ND
Pahrump, Nevada		1000	12/4	46.5	X X	PF	0.8 0.1	No Gamma Scan				
158	46	0915	12/6		10 1009	CC		ND	ND	ND	ND	ND
		0915	12/6	22.8	11 1400	PF	3.8 0.31	0.4 0.03	1.0 0.08	ND	ND	ND
		0800	12/7		29 1842	CC		ND	ND	ND	ND	ND
		0800	12/7	25.2	17 1957	PF	2.4 0.22	0.1 0.009	0.8 0.07	ND	ND	ND
		0900	12/8		28 1300	CC		ND	ND	ND	ND	ND
		0900	12/8	24.0	12 1805	PF	0.4 0.03	ND	0.3 0.03	ND	ND	ND
		1000	12/9		X X	CC	No cc run					

APPENDIX C. EP III - Positive Air Sampling Results

(Activity Extrapolated to End of Collection Period)

LOCATION		TIME	DATE	SAMPLING	TIME-DATE	COLL.	GROSS BETA	ISOTOPIC RESULTS (pCi/m³), (μCi·sec/m³)				
Azimuth	Distance	on / off	on / off	PERIOD * (hours)	OF GAMMA SCAN	MEDIUM	(pCi/m³) (μCi·sec/m³)	131 I	132 Te	133 I	135 I	141 Ce
Pahrump, Nevada (cont)		1000	12/9	23.6	X	PF	0.6	No Gamma Scan				
					X		0.05					
158	46	1000	12/10		X	CC	No CC Run					
					X							
Seligman, Arizona		0700	12/6	24.0	X	PF	PF not received					
					X							
119	217	0700	12/7		28	CC	ND	ND	ND	ND	ND	
					1520							
		0700	12/7	24.0	17	PF	3.2	0.3	1.2	ND	ND	ND
					1923		0.27	0.03	0.1			
		0700	12/8		X	CC	No CC run					
					X							
		0700	12/8	24.0	X	PF	.06	No Gamma Scan				
					X		0.05					
		0700	12/9		X	CC	No CC run					
					X							
Winslow, Arizona		0800	12/5	28.0	8	PF	LT(0.1)	ND	ND	ND	ND	ND
					1410							
112	336	1155	12/6		10	CC	ND	ND	ND	ND	ND	ND
					1300							
		1200	12/6	24.0	10	PF	1.9	0.1	0.5	ND	ND	ND
					2053		0.16	0.009	0.04			
		1155	12/7		28	CC	ND	ND	ND	ND	ND	ND
					1400							
		1200	12/7	24.0	17	PF	4.8	0.4	2.1	ND	ND	ND
					1923		0.41	0.03	0.18			
		1155	12/8		X	CC	No CC run					
					X							
		1200	12/8	24.0	17	PF	4.4	ND	0.8	ND	ND	ND
					2038		0.38		0.007			
		1155	12/9		X	CC	No CC run					
					X							

APPENDIX C. EP III - Positive Air Sampling Results

(Activity Extrapolated to End of Collection Period)

LOCATION Azimuth	Distance	TIME on off	DATE on off	SAMPLING PERIOD * (hours)	TIME-DATE OF GAMMA SCAN	COLL. MEDIUM	GROSS BETA (pCi/m^3 / $\mu Ci \cdot sec/m^3$)	ISOTOPIC RESULTS (pCi/m^3), ($\mu Ci \cdot sec/m^3$) 131 I	132 Te	133 I	135 I	141 Ce
Winslow, Arizona (cont)		1200	12/9	24.0	17 2133	PF	1.5 / 0.15	ND	ND	ND	ND	ND
		X			X	CC	No CC run					
Barstow, California		1155	12/10		X							
		0700	12/6	24.0	X	PF	0.2 / 0.02	No Gamma Scan				
197	140	0700	12/7		X	CC	No CC run					
		0800	12/7	24.0	12 1840	PF	1.3 / 0.11	0.1 / 0.009	0.5 / 0.04	ND	ND	ND
		0800	12/8		X	CC	No CC run					
		0700	12/8	24.0	12 1745	PF	1.5 / 0.13	0.1 / 0.009	0.4 / 0.03	ND	ND	ND
		0700	12/9		X	CC	No CC run					
		0700	12/9	24.2	17 2020	PF	.8 / 0.07	ND	ND	ND	ND	ND
		0700	12/10		X	CC	No CC run					
Death Valley Jct., Calif.		0720	12/4	23.8	11 1630	PF	13 / 1.1	ND	0.5 / 0.04	ND	ND	ND
192	38	0700	12/5		28 1250	CC		ND	ND	ND	ND	ND
		0700	12/5	24.0	X	PF	2.5 / 2.2	No Gamma Scan				
		0700	12/6		10 1128	CC		ND	ND	ND	ND	ND
Lone Pine, Calif		1300	12/5	24.0	X	PF	0.2 / 0.02	No Gamma Scan				
261	100	1300	12/6		X	CC	No CC run					

APPENDIX C. EP III - Positive Air Sampling Results

(Activity Extrapolated to End of Collection Period)

LOCATION Azimuth	Distance	TIME on off	DATE on off	SAMPLING PERIOD * (hours)	TIME-DATE OF GAMMA SCAN	COLL. MEDIUM	GROSS BETA (pCi/m^3 / $\mu Ci \cdot sec/m^3$)	ISOTOPIC RESULTS (pCi/m^3) / ($\mu Ci \cdot sec/m^3$) 131 I	132 Te	133 I	135 I	141 Ce
Lone Pine, Calif (cont)		1300	12/6	72.0	17 2149	PF	1.4 0.36	0.1 0.03	0.3 0.08	ND	ND	ND
261	100	1300	12/9		X X	CC	No CC run					
		1300	12/9	24.0	X X	PF	1.0 0.09	No Gamma Scan				
		1300	12/10		X X	CC	No CC run					
Needles, California		1508	12/4	64.0	12 1710	PF	1.5 .36	0.1 0.02	0.4 0.09	ND	ND	ND
146	167	1712	12/7		X X	CC	No CC run					
		0713	12/7	26.2	17 2038	PF	23 2.2	ND	ND	ND	ND	ND
		0929	12/8		X X	CC	No CC run					
		0930	12/8	20.9	X X	PF	1.7 0.13	No Gamma Scan				
		0724	12/9		X X	CC	No CC run					
Ridgecrest, Calif		1218	12/6	25.3	X X	PF	LT(0.2)	No Gamma Scan				
223	113	1333	12/7		X X	CC	No CC run					
		1333	12/7	22.1	12 1840	PF	0.8 0.07	0.1 0.008	0.4 0.03	ND	ND	ND
		1142	12/8		X X	CC	No CC run					
		1145	12/8	26.5	X X	PF	0.7 0.07	No Gamma Scan				
		1405	12/9		X X	CC	No CC run					

APPENDIX C. EP III - Positive Air Sampling Results

(Activity Extrapolated to End of Collection Period)

LOCATION Azimuth	Distance	TIME on / off	DATE on / off	SAMPLING PERIOD * (hours)	TIME-DATE OF GAMMA SCAN	COLL. MEDIUM	GROSS BETA (pCi/m^3 / $\mu Ci \cdot sec/m^3$)	ISOTOPIC RESULTS (pCi/m^3), ($\mu Ci \cdot sec/m^3$) 131 I	132 Te	133 I	135 I	141 Ce
Shoshone, California		1042	12/4	23.1	9 0918	PF	2.0 0.17	0.1 0.008	0.8 0.06	ND	ND	ND
178	60	0950	12/5		X X	CC		No CC run				
		0952	12/5	23.8	X X	PF	3.4 0.29	No Gamma Scan				
		0940	12/6		10 1600	CC		ND	ND	ND	ND	ND
Durango, Colorado		1731	12/4	24.0	X X	PF	LT(0.1)	No Gamma Scan				
086	464	1730	12/5		X X	CC		No CC run				
		1731	12/5	24.0	X X	PF	6.9 0.59	0.4 0.03	0.9 0.08	ND	ND	ND
		1730	12/6		X X	CC		No CC run				
		1731	12/6	23.6	12 1710	PF	7.2 0.62	0.5 0.04	2.0 0.17	ND	ND	0.2
		1710	12/7		X X	CC		No CC run				
		1711	12/7	24.4	13 1525	PF	3.6 0.32	0.8 0.07	2.5 0.22	ND	ND	ND
		1730	12/8		X X	CC		No CC run				
		1804	12/8	23.3	X X	PF	0.8 0.07	No Gamma Scan				
		1830	12/9		12 1810	CC		ND	ND	ND	ND	ND
Albuquerque, N.M		1500	12/4	25.8	8 1555	PF	0.2 0.02	ND	ND	ND	ND	ND
103	552	1645	12/5		X X	CC		No CC run				

APPENDIX C. EP III - Positive Air Sampling Results

(Activity Extrapolated to End of Collection Period)

LOCATION Azimuth	Distance	TIME on / off	DATE on / off	SAMPLING PERIOD* (hours)	TIME-DATE OF GAMMA SCAN	COLL. MEDIUM	GROSS BETA (pCi/m^3 / $\mu Ci \cdot sec/m^3$)	ISOTOPIC RESULTS (pCi/m^3), ($\mu Ci \cdot sec/m^3$) 131 I	132 Te	133 I	135 I	141 Ce
(cont) Albuquerque, N. M.		1645	12/5	22.8	8 1230	PF	16 1.3	0.8 0.06	3.3 0.27	2.5 0.20	ND	ND
103	552	1530 X	12/6		X	CC	No CC run					
		1530	12/6	22.3	17 2035	PF	28 2.3	1.9 0.15	7.6 0.61	ND	ND	ND
		1350	12/7		X	CC	No CC run					
		1350	12/7	27.6	17 1938	PF	2.6 0.25	ND	0.4 0.04	ND	ND	ND
		1725	12/8		X	CC	No CC run					
		1725	12/8	23.0	X X	PF	1.3 0.11	No Gamma Scan				
		1624	12/9		X X	CC	No CC run					
Enterprise, Utah		1510	12/4	24.0	11 1555	PF	8.4 0.73	0.1 0.01	1.3 0.11	ND	ND	ND
070	150	1510	12/5		17 2255	CC						
		1510	12/5	24.0	17 2000	PF	2.9 0.25	ND	ND	ND	ND	ND
		1510	12/6		28 0920	CC		ND	ND	ND	ND	ND
Milford, Utah		1200	12/4	24.0	X X	PF	LT(0.2)	No Gamma Scan				
059	209	1200	12/5		X X	CC	No CC run					
		1200	12/5	24.0	12 1730	PF	6.1 0.53	0.3 0.03	1.7 0.15	ND	ND	0.1 0.009
		1200	12/6		X X	CC	No CC run					

APPENDIX C. EP III - Positive Air Sampling Results

(Activity Extrapolated to End of Collection Period)

LOCATION Azimuth	Distance	TIME on off	DATE on off	SAMPLING PERIOD* (hours)	TIME-DATE OF GAMMA SGAN	COLL. MEDIUM	GROSS BETA (pCi/m^3 / $\mu Ci \cdot sec/m^3$)	ISOTOPIC RESULTS (pCi/m^3) / ($\mu Ci.sec/m^3$) ^{131}I	^{132}Te	^{133}I	^{135}I	^{141}Ce
Milford, Utah (Cont)		1200	12/6	24.0	X	PF	0.3	No Gamma Scan				
					X		0.03					
		1200	12/7		X	CC	No CC run					
					X							
059	209											
Monticello, Utah		1230	12/5	24.0	X	PF	3.7	No Gamma Scan				
					X		0.32					
		1230	12/6		X	CC	No CC run					
					X							
079	388											
		1230	12/6	26.0	X	PF	2.8	0.1	0.9	ND	ND	ND
					X		0.26	0.009	0.08			
		1430	12/7		X	CC	No CC run					
					X							
Parowan, Utah		1000	12/4	24.0	11	PF	13	0.3	0.9	ND	ND	ND
					1555		1.2	0.03	0.08			
070	202											
		1000	12/5		X	CC	No CC run					
					X							
		1000	12/5	24.0	X	PF	0.2	No Gamma Scan				
					X		0.02					
		1000	12/6		X	CC	No CC run					
					X							

PF = Particulate Filter

CC = Charcoal Cartridge

LT = Less Than

ND = Not Detected

X = Information not available

* Sampling periods for permanent ASN stations are from time meter readings and not ON/OFF times recorded by station operators.